



Analysis of Maryland Port Facilities for Offshore Wind Energy Services

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State of Maryland, Maryland Energy Administration

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Executive Summary

What is the offshore wind opportunity for Maryland Ports: How suitable are the ports? What is required to make them competitive?

To capture long-term offshore wind project value for port operation, Kinetik Partners recommends that the state of Maryland engage with industry to catalyze the development and improvement of port infrastructure at Sparrows Point's SPSIC. We propose a two-tiered strategy: a near-term tactical approach to establish operational momentum and a longer term cluster development strategic approach. For the near-term tactical approach with execution over the next 1-3 years, we recommend seeking to locate port operations for an upcoming offshore wind park at Dundalk Marine Terminal or SPSIC, with Dundalk being in a higher state of readiness. For the long term strategy beyond 3 years, we recommend establishing operations at Sparrows Point.

These two strategies are consistent with the two primary ways that port operations for offshore wind are developed: the developer based model and the industrial and innovation cluster based model for offshore wind farm port development.

Project Developer Based Port Development for Maryland

Dundalk Marine Terminal

Our analysis of the port operations in Maryland has identified two primary areas in Maryland that Kinetik Partners recommends for detailed study of development potential for offshore wind in the near term over the next 1-3 years. The first area, the Dundalk Marine Terminal, is an optimal early entrant for the offshore wind supply chain in Maryland. Given that the current supply chain in the US is immature for offshore wind turbine components, it will consist of imported components.

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Dundalk has the proper equipment to handle break bulk cargo, which is the type of cargo represented by offshore wind components, reinforced by its 250 ton crane already at port. This crane will handle all components for current technology 3-4 megawatt (MW) turbines. Upgrades would need to be made for offshore wind farms employing larger, 5+ MW turbines. Dundalk also has the capability for storage, warehousing, assembly of limited size components, and launch. This is of course provided that sufficient area is available. Dundalk is a currently operating marine terminal, which means that sufficient free space may not be available. Kinetik Partners is recommending 200 acres minimum for port operations, with the assumption that over the medium to long term, successful ports will need to develop into an offshore wind cluster. With NRG Bluewater leasing 117 acres at Quonset, RI, this land area can be considered a lower bound of short-term feasibility for offshore wind port operations.

Sparrows Point

The second area identified is the Sparrows Point Shipyard Industrial Complex (SPSIC), the former Bethlehem Shipyards at the southwest corner of the larger Sparrows Point land area. This area has some critical assets that make it attractive for offshore wind development staging in the near future and over the long term. Its ample land area is a critical asset for offshore wind port development, as well as well as a positive economic development opportunity to convert a brownfield facility into a clean energy facility. The SPSIC totals 250 acres and is fully available. Depth of port and berths available is another critical consideration. The graving dock provides at least one berth and Pier 1 may provide a second berth. The twin 200 ton cranes at the graving dock provide sufficient lifting capability to handle current generation offshore turbines. The single berth currently suitable for offshore projects will limit this facility, as will the ramp up of its basic capabilities after years of limited activity. However, over the medium to longer term, these limitations can be overcome with some investment. With SPSIC residing on a larger 2,300 acre under-utilized facility, the potential space for development far exceeds any large-scale cluster that could be developed.

Cluster Based Port Development for Maryland

A cluster based development for offshore wind port development in Maryland needs to be an integrated public private partnership which works on critical portions across the entire offshore wind value chain. Key driving participants in this partnership include the Maryland Department of Business & Economic Development, the Maryland Energy Administration and local businesses. In addition, this base should actively seek to attract and involve new businesses with skills and experience in offshore wind that are not represented among the local base of industry. Since renewable energy is a regulatory driven market, it will be necessary to leverage the state's delegation to the US Congress and the state Governor. We recommend that the state of Maryland pursue the following portions of the supply chain to develop the offshore wind port cluster: wind turbine original equipment manufacturers (OEMs); rotor blade manufacturers; steel suppliers for foundations, towers and large castings (covered in another Kinetik Partners report to the Maryland Energy Administration); offshore wind construction companies. In addition, it can reinforce the cluster with development facilities focused on the deployment of very large turbines on site.

Cluster Location

Kinetik Partners' analysis shows that the Sparrows Point Shipyard Industrial Complex is an excellent candidate for developing an offshore wind cluster with port operations for launching offshore projects. It has the area needed, relevant port infrastructure from which to build and all other necessary infrastructure requirements. Sparrows Point has the unique opportunity to co-locate a port with a heavy steel component manufacturing cluster. It is possible to co-locate offshore vessel shipbuilding operations at the site as well. By combining the port operations with OEMs and their critical suppliers, including heavy steel manufacturing, at one site, Maryland can overcome its location disadvantages (based on distance to projects compared to other potential port sites) and become the leading site for offshore wind in the Eastern United States.

Wind Turbine Original Equipment Manufacturers (OEMs)

OEMs are a critical link for an offshore wind port cluster. After developers select locations and get the permitting and detailed site study process underway, the next task is to select a partner OEM. Market leaders are currently Siemens and Vestas with their 3.6 MW and 3.0 MW machines respectively, with Gamesa, Alstom, and Areva coming to market in the next 12 to 24 months with newer, bigger, cheaper machines. These are the companies that should be targeted for attraction to an offshore wind port development.

Development Site

As part of an offshore wind port cluster at Sparrows Point, we recommend facilitating the installation of multiple test beds both onshore and offshore in shallow water for turbines in the range from 5-7 MW. The turbine test sites could be located on the Sparrows Point campus and nearby in the Chesapeake Bay for additional validation in an offshore environment and to supply power into the RG Steel campus. The ability to test the turbines in a controlled manner at low risk and cost to deploy offshore is of high value to OEMs.

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Introduction

The Maryland Energy Administration (MEA) has commissioned the “Analysis of Maryland Port Facilities for Offshore Wind Energy Services” study to understand the potential impact of the burgeoning offshore wind industry in the East Coast.

Furthermore, this analysis will focus on understanding current capabilities of Maryland ports to support the proposed offshore developments on the east coast. We will provide an analysis and recommendation to maximize the economic development potential for Maryland businesses and economy.

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GRATEFUL APPRECIATION TO PARTNERS

During this Study a number of organizations and individuals were consulted to ascertain their views on offshore wind technology and also to obtain relevant supporting information. We would like to thank all those who contributed including the following:

- Shawn Kiernan, Strategic Planner, Maryland Port Administration
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- Jerry Nelson, Business Development, RG Steel
- Jens Eckhoff, Board Member, WAB

Objectives and Approach

Overview

In October 2011 the Maryland Energy Administration, issued a class III small procurement Request for Proposal (RFP) for the "Analysis of Maryland Port Facilities for Offshore Wind Energy Services." The Maryland Energy Administration (MEA) is an agency of the State of Maryland. MEA is authorized by State law to maximize energy efficiency, increase the use of renewable and clean energy sources, and improve the environment. MEA is also engaged in the broader issues of sustainability, climate change and alternative transportation fuels and technologies. The MEA awarded contract number 2012-03-121S2 to Kinetik Partners to complete the aforementioned study.

Selection of Kinetik Partners

Kinetik Partners (KP) was selected to perform this study based on our knowledge and experience in the global wind energy markets, growth strategy design, and technology innovation for both public and private sector clients.

Project Scope and Objectives

The project objective is to develop an understanding of the Maryland region's ports, facilities and capabilities to support offshore wind developments. Additionally we will compare Maryland's ports with other Mid-Atlantic ports, such as the ports of Virginia and Wilmington.

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The scope of the project includes the review and identification of port infrastructure requirements including vessel access and utilization, documentation of Maryland port capabilities, and analysis of the state of readiness for Maryland ports to service Atlantic Coast offshore wind system deployments.



Figure 1: Offshore Wind Port Bremerhaven (Source: BIS, Photograph W. Scheer)

This report contains infrastructure requirements and analysis of the suitability of Mid-Atlantic ports for the deployment of offshore wind systems. The following issues are addressed in the report:

- Work Breakdown Structure (WBS) for key and systems and components.
- Offshore turbine assembly process as it applies to port logistics.
- Port infrastructure requirements.
- Maryland and Mid-Atlantic port facility/infrastructure assessment.
- Port location relative to steel fabrication facilities and offshore deployments.

Project Approach and Methodology

We have based our report on the infrastructure required for the installation of standard architecture wind turbines from 3.6 MW to 5 MW in shallow or transitional waters. The project is divided into three tasks:

1. Offshore port infrastructure requirements

Kinetik has completed a WBS of offshore wind systems as it applies to large shipped components. This will produce a generic document, indicating weight of large components (e.g., blades, nacelles, towers, foundations.) that must be handled by ports. Additionally, Kinetik has reviewed the offshore turbine assembly process, detailing the type of infrastructure and vessels required for delivery, installation, maintenance and servicing of offshore wind turbines.

Kinetik has developed a comprehensive infrastructure requirement table for port facilities. This analysis takes into account how future technology developments, such as different floating platforms for transitional and deep-water applications, potentially impact port infrastructure and allow ports to avoid major investments.

Subsequently, Kinetik has identified and mapped all proposed Mid-Atlantic offshore projects. These will be later use as inputs to task 3.

2. Maryland and Mid-Atlantic port infrastructure assessment

Kinetik has identified five comparable Mid-Atlantic ports and one in the New England: two in Maryland, one in Virginia, one in New Jersey, one in Delaware, and one in Rhode Island; highlighting port infrastructure capabilities (e.g., material handling, staging areas) along with key access constraints (e.g., bridge clearances, channel depth) to access key Mid-Atlantic offshore projects.

3. Port suitability for offshore deployment

Lastly, Kinetik has mapped offshore infrastructure requirements to the regional port infrastructure capabilities in order to analyze gaps and opportunities. This section provides recommendations for the Maryland Energy Agency (MEA) and Maryland port facilities to maximize opportunity.

This project provides the answer to the following questions:

- a. Does the port have the required assets to become an offshore wind hub? If not, identify gaps and opportunities.
- b. What are the vessels required for offshore wind deployment?
- c. Where are the proposed Mid-Atlantic offshore wind projects?
- d. Do the proposed ports provide access to offshore wind developers?
- e. Where are the Maryland steel fabrication hubs located with respect to proposed ports and offshore projects?

This report details the state of readiness of Maryland's port infrastructure to service US offshore wind energy project deployments with consideration for shipping, handling, staging of large offshore wind turbine components. It also considers the needs of specialized vessels that support the delivery, installation and maintenance of offshore wind systems and components. In addition, the report presents the study of requirements, analysis and recommendations to maximize the economic development opportunity that Maryland port infrastructure can offer to the state and the offshore industry.

Offshore Wind Port Infrastructure Requirements

This section provides a brief description of the components required to develop and deploy a wind farm. It additionally describes the deployment process including details on infrastructure and vessel requirements.

Wind Farm Components and Shipping Methodology

There are five large components per turbine, plus the foundation and substation. The turbine components are: tower, nacelle, hub, blades, and transition pieces. When considering the number of components, there are multiple ways to transport the turbines to the project sites. Here we discuss the most prevalent methods and some of the component dimensions.

Table 1- Key Components Specifications for Offshore Turbines

Model	Power(MW)	Hub (t)	Blade (t)	Rotor (t)	Nacelle (t)	Tower (t)	Total (t)
Vestas V80	2	18	6.5	37.5	69	155	216.5
Siemens 2.3	2.3	32.3	9.2	60	82	130	272
Vestas V90	3	40	9	67	70	110	247
Siemens 3.6	3.6	42.4	17.2	95	125	180	420
Areva M5000	5	62	16.5	110	233	200	543
RePower 5	5.075	84	24	156	290	210	656
RePower 6	6.15	84	24	156	316	285	757
Vestas V164	7		35	227.5	+/- 390		

Foundation

Foundations are typically installed prior to the shipment of the turbine pieces. While there are different types of foundations, the shipping methodology is common between different sites. The pictures below illustrate the transportation and installation of Weserwind foundations in the Baltic Sea.



Tower

Towers are usually shipped vertically on a barge. The determining factor for the number of towers that can fit on a barge is the amount of onshore preassembly of the nacelle and rotor. The pictures in the next subsections show different shipping configurations on the barge.

Turbine Nacelle and Rotor

We see three different methods of shipping nacelle and rotors.

- I. Separate nacelle, hub and blades: the picture below shows RePower port staging operations loading barges with six turbine nacelle sets. The blades are shipped independently from a different facility and subsequently assembled at the offshore site.

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- II. Bunny Ear Formation: the nacelle and hub are preassembled onshore along with two of the blades attached and protruding upwards. Sometimes the hubs are not completely attached to the nacelles. This configuration lowers offshore assembly needs by attaching only one blade at sea. The picture below shows the bunny ear formation both onshore and during shipping.



- III. Ship nacelles and fully-assembled rotors separately: the rotors, hub assembly, and three blades are preassembled on shore and barged to the project site for final assembly with the nacelle. The picture below shows a self-propelled crane vessel carrying a full set of components for four complete turbines. One tower and nacelle have been assembled while a rotor is lifted for attachment. Three sets of nacelles and rotors and six tower pieces remain on the vessel.

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Sub Station

The final piece of the offshore wind project is the installation of the substation. These systems have their own foundation design, which is usually a large gravity foundation. The stations are carried to sea on a barge and positioned in place with two cranes. These substations can weight in excess of 1,000 tons.



Table 2 below describes some of the general dimensions and weights of the major components required to install an offshore wind farm.

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Table 2: Offshore Wind Components – Weights and Dimensions

Approximate Mass and Max Dimension		
Component	5 MW	3 MW
Tripod	850 tons, L/W/H 32/32/60 m	
Jacket Concrete	3000 tons, D 30–40 m, H 60 m	550 tons, L/W/H 20/20/60 m
Monopile	300 tons, D 5.5–7 m, L 60 m	
Tower Segment	125 - 150 tons, 35 m tall	77 tons, 33 m tall
Nacelle	350 tons, L/W/H 21/8/9 m	165 tons, 14m long
Rotor Blade	25 tons, D 5 m L 65 m	15 tons, D 5 m L 55 m
Rotor Hub	35 tons, D 6 m L 6 m	18 tons D 4 m L 5 m
Complete Rotor	150 tons D130m L 6m	100 tons D110m L 5m
Rotor Bunny Ears	110 tons L/W/H 6/120/20 m	85 tons L/W/H 5/110/15 m
Sub Station	1,000 tons, L/W/H 34/27/24 m	

Source: Vestas, Areva, KP, Tetrattech

Figure 2: Major Offshore Wind Turbine Components and their Largest Dimension



Offshore wind project deployment process

Relative to onshore wind turbines, offshore turbines have higher capital costs due to marine adaptations and upgrades for operation, foundations, balance-of-plant, installation and interconnection. In addition, significant capital investment is required to develop the infrastructure necessary to support the offshore industry including: vessel production, port/harbor adaptation, manufacturing infrastructure and qualified workforce.

To date, most offshore wind foundation structures have been monopile and gravity systems. These foundation systems are suitable for shallow waters, up to 30m, and medium-sized machines: 2-4 MW. As new, larger machines with significantly greater top head mass (300-400 tons) come to market, stronger foundations are required. Thus, tripods and heavy jackets were developed to provide the foundation needed for the larger machines. These foundation systems also provide access to transitional waters up to 60m. For deeper waters, more appropriate technologies such as tension leg platform (TLP), semi-submersible platforms, or mono floating structures (spar buoy) simplify the foundation process. These types of oil and gas derived floating platforms are starting to be deployed for testing because of the significant promise they offer in the construction and deployment process.



Onsite marine construction can be significantly more expensive (four to eight times) than the same work performed in a factory environment¹. Specialized at-sea equipment, barges and ships can require significant investment in local shipbuilding, maintenance and repair infrastructure. Thus, the industry trend is to maximize the preassembly of components at the port to minimize time at sea, as in the case of the Beatriz demonstration in Scotland, pictured above, wherein a complete turbine was built onshore and then transported by barge to the installation site.

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The likely wind turbine platform technology roadmap will lead to the development of floating platforms upon which entire wind turbine generator systems will be assembled in a weather-secure location and then tugged to the development site for rapid installation. EDP in Portugal is the first to deploy onshore assembly floating platforms. The picture below shows the 2MW Vestas machine being towed on a "windfloat" platform. (Photo: WindFloat platform being towed, source: Bourbon)



Assembly concepts and process

The assembly and installation process of the wind farm generally follows a 7 step process, described below and using UK prices as reference.

- I. Export laying cable
 - a. This activity is the installation of cable connection between the onshore and offshore substations. Using a cable installation vessel, cables are laid as long as possible in one of two manners:
 - i. Simultaneous lay and burial of cable using a cable plough. New ploughs typically cost \$15 million in the UK.

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- ii. Cable is laid on sea floor and subsequently buried using a trenching remote operated vehicle and vessel. Daily trenching vessel and ROV rates typically cost \$100,000 to \$150,000.

II. Foundation installation

- a. This activity entails the transport and fixing of foundations in position. This function requires a foundation installation vessel. The process involved varies with the type of foundation chosen. Monopiles typically are driven from a jack-up vessel but can be installed using a floating vessel. Jacket and tripod foundations may be installed by floating cranes. Gravity base foundations may use floating cranes or specialized barges to support float-out. Monopiles are driven into the seabed using a sea hammer before mounting transition pieces on top. Jacket and tripod foundations use multiple pin piles driven into the seabed and subsequently grouted. Offshore substation foundations may be installed in a similar way to turbine foundations but are significantly larger. Cables are drawn from the seabed through a J-tube into the foundation base to feed up to the wind turbine.

- i. The foundation installation vessel transports foundations from the port fabrication facility to the site and installs them in the seabed. Types of vessels used are: self-propelled jack-up vessels, towed jack-up barges, floating cranes. Daily charter rates are typically \$200,000 for self-propelled jack-up vessels while floating cranes could cost \$300,000/day.
- ii. Monopiles typically are installed using jack-up vessels and sea hammers, whereas cranes can install jackets and tripods.

III. Array cable laying

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- a. This activity connects the cables between the turbines and the offshore substation. Typically installed by an array cable-laying vessel, cables are laid in a networked pattern.
- b. Array cable-laying vessels typically cost \$100,000 to \$150,000 daily. The vessel can be a barge with special tension cable-laying equipment.

IV. Construction port

- a. The port is the base of preassembly for deployment of equipment to the installation site. According to an interview with a developer conducted for the state of Massachusetts, the ideal port would have a 1000 ton capacity crane on tracks to unload from a vessel and carry directly to storage, enough linear footage to efficiently unload several vessels at a time and at least 200 acres of for assembly and storage. Based on European data, the minimum characteristics of a staging port are:
 - i. 24 ft of water depth at low tide
 - ii. 2 berths, at 450 ft each
 - iii. 150 ft air draft
 - iv. Short distance to project site
- b. Harbor side water depth requirements are such that they should meet the dimensions of the deepest draft vessel which will be used (most likely a large cargo ship). Depending on future installation and transport methods (such as floating a fully-assembled turbine on platform to installation site), vertical clearance requirements could exceed 200 meters (650 ft).
- c. On the landside, the port should have adequate space for delivery, storage, and assembly. Typically the components are in a lay-down

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position. For large turbines, 200 acres is ideal, although smaller sites have been developed.

- d. Some additional, but not required, characteristics of an ideal staging port include interior storage or fabrication (such as a large warehouse of approximately 50,000 sq. ft.), office space, and worker accommodations.
 - e. Onshore construction areas require space for delivery, storage and assembly. While the amount of space needed depends on each project size, the two proposed offshore wind staging ports on the US East Coast will use 112 and 150 acres in total. Storage serves two functions: 1) having a stock of turbine components ready for deployment, and 2) temporary storage for staged components waiting to be deployed based on weather.
 - f. Handling equipment: some of the necessary handling equipment for the staging port is as follows: large crawler cranes, medium crawler cranes, truck mounted cranes, cherry pickers, forklifts, transport vehicles, trailers and low loaders.
 - g. Load bearing of the ground and dock is of special consideration considering the size and weight of components that are being manipulated. Loads can exceed 2,000 lbs/sq. ft.; thus the ground and docks should be reinforced accordingly.
- V. Offshore substation installation
- a. Based on Hochtief's installation at the Alpha Ventus offshore site, offshore substations are typically 60 m high and weigh 1,300 mt. Prefabricated steel structures are transported to the port's loading quay, aligned, measured, and welded together. At sea, using a jacket foundation as an example, the foundation size has a height of 45m and

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weight of 580 mt. The jacket foundation is anchored to the seabed with four piles, 100 mt each, which go through the following operations:

- i. Transported via jack up crane
- ii. Pile-driven into ground
- iii. Piles are grouted

It is additionally comprised of a topside: electro technical units each 15 m high (protruding 30 m above sea) and weighing 680 mt. This topside is made up of a helicopter deck, main deck, and cable deck. Typically it is transported via floating crane to the destination site and placed on top of the foundation.

VI. Sea-based support

- a. Several kinds of vessels will be used in various functions for support during installation. Daily costs depend on type of vessel. Vessel functions will be: crew transport, remote operated vehicles and diving vessels.

VII. Turbine installation

- a. This activity entails transporting turbine components from port to installation site and conducting site installation activities. An example of this using the Areva Multibrid M5000 would be as follows:
 - i. Insert partial tower (residing on jack-up barge) into transition via jack-up barge crane
 - ii. Insert partial tower (residing on jack-up barge) into lower tower via jack-up barge crane
 - iii. Tug rotor, nacelle in star formation on jack-up barge to location, jack up
 - iv. Place nacelle on top of tower via jack-up barge crane

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- v. Lift, attach fully assembled rotor via jack-up barge crane

Different permutations of installation activity order exist, based on port and logistic infrastructure. These activities require different types of vessels such as jack-up barges, floating cranes and barge cranes.

VIII. Commissioning

- a. This is the “turn key” portion of activities. Depending on contract terms, this is the stage when final performance checks are made prior to formal operation.

Port Infrastructure Requirements for Offshore Wind

Port Requirement Development

Kinetik Partners has developed the following port infrastructure requirements by analyzing the work breakdown structure for port assembly procedures while referencing the port of Bremerhaven², which recently completed a port upgrade to add infrastructure to accommodate offshore wind staging operations. We also made use of multiple data sources from European organizations and US offshore wind port developments at Wilmington, Delaware and Quonset, Rhode Island. We followed the flow of material for building an offshore wind farm from receiving inbound materials via sea and land, to handling and processing those materials in the port, to staging components for transport to the wind farm site, and lastly to outbound logistics for moving the components from port to project.

Inbound Logistics

Inbound logistics must be considered for the port facility. Even an offshore wind project staged at a well-functioning offshore wind cluster with substantial local manufacturing and assembly will need to import numerous components of various sizes from multiple regional and international sources. Especially in the beginning of the US offshore wind industry, many large components will be delivered from

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Europe as the local supply chain will not have been developed in the US. Therefore, a US port for offshore wind development must have a berth dedicated primarily to receiving cargo ships carrying inbound wind components.

One example of a ship which would serve a dedicated offshore wind port is the BBC Konan operated by BBC Chartering (picture below). This ship has a length of 126.5 meters (415 ft), width of 20.3 meters (67 ft), and max draft of 6.65 meters (22 ft). Air draft of incoming and outgoing vessels is a consideration as well. Generally, requirements of offshore wind construction, transportation, and crane vessels will drive port size requirements, but it is worth noting the global Panamax standard dimensions (the maximum dimensions of a cargo ship that can pass through the locks at the panama canal): length – 950 ft, width – 106 ft, draft – 39.5 ft, air draft – 190 ft, which is commonly used for international transport.



The orientation of the berth should be parallel to the port land area, with adjacent staging and transportation zones as discussed below. Ports with berths at piers which extend perpendicular to the port land area will not accommodate offshore wind project staging operations unless they are at least 30 meters wide (98 ft) and can handle 2,000 pounds per square foot.

Ports must also have ready access to major highways for trucked components and rail access for inbound materials and components via rail. As offshore wind turbines grow from the 3-4 MW range for current technology towards 5-6 MW machines which are coming to market in the next 12-24 months, over-road trucking and rail for the delivery of assembled nacelles will become less feasible. However, trucking operations will remain important in the transport of smaller subsystems and components for final assembly at the port facility. Larger turbines will heighten the need for inbound ocean shipping and for developing offshore wind turbine supplier parks and manufacturing facilities at ports.

Inbound Logistics establish the following criteria:

- Minimum shipping channel and portside depth of 24 feet at low tide.
- Minimum berth length of 450 feet for inbound shipping vessels.
- Berths parallel to the port land area, or with substantial peers that can accommodate heavy loading of 2,000 pounds per square foot with a width of 98 feet.

Port Side Operations

Port side operations must be considered. These activities include:

- Crane lifting for offloading inbound cargo and loading outbound cargo.
- Staging components dockside to be loaded onto barges and transport vessels for installation at the wind farm site.
- Assembling components such as rotors, foundations, jackets, tower sections and transformer substations.
- Storing components in a lay down area to ensure enough inventory is at the site to facilitate uninterrupted assembly and shipping operations.
- Transporting large components from inbound ships to the lay down and assembly area, and conversely from the lay down and assembly area to dockside for staging.

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- Transportation and assembly vessel docking and maneuvering to pick up components for delivery to wind farm.
- Other operations onsite - office space, fabrication buildings, warehouse space, etc...

Crane lifting

Table 2 shows pick weights for offshore wind components for 3 MW and 5 MW turbines. Heavy foundations are not included due to the industry movement away from that technology and its limited use in projects to date. The maximum weight for a 3 MW component is 300 tons for monopile foundations, while the maximum component weight for a 5 MW turbine is 850 tons for a tripod foundation. In addition, a 5 MW nacelle weighs 350 tons. While the transformer substation will weigh between 1,000 tons and 1,300 tons, there will likely be only one for any given installation, whereas many tripod foundations will be needed for larger turbines, therefore a crane capable of lifting these will be needed on the dock.

Area Considerations

Our analysis suggests that a minimum requirement of 50-75 acres of dock area is necessary, complemented with an additional 100-150 acre assembly, storage and inventory area. On average, for a standard farm, a total of 150-200 acres are necessary at the port to support offshore wind farm deployment.

In the US, Deepwater Wind has leased 117 acres at Quonset Business Park³. Kinetik Partners' analysis of NRG Bluewater's plans at the port of Wilmington, Delaware reveals that approximately 150 acres were being proposed for staging two offshore wind projects. A project developer commented on an ideal port for staging offshore wind projects:

A port would have a 1,000-ton crane on rolling tracks, which would carry components from a delivery vessel to a storage location; sufficient linear footage to efficiently load/unload one vessel at a time, with a preference for multiple deepwater berths to unload several vessels simultaneously; a secondary 80-ft berth; and about 200 acres for assembly and storage.⁴

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The latest port to come on line, fully specialized in offshore wind, is the Bremerhaven offshore industrial complex located in Bremerhaven, Germany. This group is focused on the development of a competency and innovation cluster around the port facility. The port is a 25 hectare (62 acre) dock facility, coupled with a 200 hectare (450 acre) supplier park for other dedicated offshore operations and logistics. Approximately 200 acres are in operation housing two OEMs, a blade manufacturing facility and two tower and foundation fabricators, as well as multiple R&D, service and logistics companies. This clustering initiative has brought over 1,500 direct jobs to the area within the last 5 years.

Staging Components

The port at Bremerhaven has capacity for up to 160 wind turbines and foundation structures per year and lists its dock area as 25 ha (62 acres at the wharf side). The port lists its functional capabilities as: staging area for 6 foundation structures, 18 tower segments, 6 hubs, 6 nacelles, and 18 rotor blades; in addition to staging area for transportation and lifting equipment. The area breakdown for staging is listed as 15%, yielding approximately 10 acres needed for staging components for immediate loading.⁵ Staging components occur directly in front of a berth to allow crane barges to pick up and load components upon demand. It is operationally efficient to stage components while unloading inbound components, therefore two berths are required and a third berth is desirable.

Component Assembly

Rotor hubs and blades will be transported into the near-dock assembly area, assembled into bunny ear configuration (and subsequently attached to the nacelle) or assembled into the star formation. Foundation structures, tower sections, and the transformer substation will be assembled from subcomponents near the dock as well. It is critical that these large components be assembled near the final loading site at the dock, because once finished, they are quite large and heavy, therefore moving them is difficult. The port at Bremerhaven notes that assembly activities take

up 43% of the 62 acres at the dock side, yielding approximately 27 acres required for assembly operations.

Lay Down Storage

Components such as nacelles, rotor blades, hubs, tower sections, and foundation pieces must be stored at the offshore wind port for assembly and then shipped out to sea for assembly at the wind park site. It is estimated that at least as much lay down storage area is needed as assembly area. Thus, using the port of Bremerhaven as an example, another 27 acres will be needed for lay down storage.

In-Port Transportation

In-port logistics at the dockside is an important consideration for port requirements. Given the large and heavy components, the dock, assembly and lay down storage areas must have very high load bearing capacity up to 2,000 lbs per square foot. Appropriate area at the dock must be allowed for transporting inbound components from their delivery ship to the appropriate assembly or lay down storage area, and then back to assembly and staging. The port at Bremerhaven lists transportation routes specifications of 30 meters (98 ft) width and 90 meters (295 ft) length. Crawler cranes with turning radius up to 30 meters (95 ft) must also be accommodated. Transportation area requirements amount to 27% of the dockside area, totaling almost 17 acres.

Other Operations Onsite

Essentially, a port for staging offshore wind projects is the combination of a large infrastructure construction project and a heavy cargo shipping operation. As such, besides the direct space needs for managing components dockside, there are other space needs for the successful management of an offshore wind port. Warehousing will be needed for a variety of purposes including storing components prior to assembly or staging for assembly operations. In addition, warehousing is needed for support logistics, such as storing trucks and crane equipment, welding equipment and tools sheds. A fabrication shop will be necessary to support all welding and

assembly operations. Offices for the project developer, contractors, and OEMs will be needed. While this list is not exhaustive, it presents a sample of the additional operations needed to support the actual dockside operations.

Port Operations establish the following requirements:

- A second berth, approximately 450 ft, to accommodate simultaneous inbound logistics and staging for outbound components
- Crane lifting capability of at least 1,000 tons
- 200 acres in total
 - 60 acres dockside for unloading, loading, staging, transportation and assembly
 - 30 acres adjacent to dockside area for laydown storage
 - 100 acres for other onsite operations
- Dockside transportation lanes at least 98 feet wide to accommodate crawler cranes and other logistics

Outbound Logistics

After the turbine components have been loaded onto barges or other offshore wind transport and assembly vessels, these ships must be able to transport their cargo from port to open sea. Turbine components can be exceptionally tall and wide, therefore vertical and horizontal clearances are important considerations that depend greatly on rotor preassembly, loading configuration, and foundation type. Blades and rotors loaded in the bunny ear configuration will rise 127 feet above the deck of the ship, assuming a 110 meter (360 ft) rotor diameter for today's 3.6 MW turbines. When rotors grow to 128 meters (420 ft) and larger for 5 MW machines, a bunny ear configuration will rise 150 feet above the vessel deck. Considering deck height above waterline, and air clearance needed between the blades and any overhead obstructions, such as bridges, overwater clearance will push towards 200 ft

as turbines grow in size. Ideally, there will be no overhead obstructions of any kind for a port, but this is quite rare for the US East Coast.

Using Areva's assembly methodology for its 5 MW machines, blade loading configuration will likely move towards the star configuration, with all three blades pre-attached to the rotor at the port and then transported flat upon the barge. In this configuration, horizontal clearance of 400 feet is needed currently and will grow towards 500 feet as larger rotor diameters come to market.

Jack up barges are require the highest air draft, as the jack-up legs raise high above the deck during loading and travel. These ships typically need 150 feet of air draft to accommodate the jack up legs.

Monopile foundations can be transported while laid flat while tower sections transported upright are 25 meters tall (82 ft). As turbine size grows to 5 MW and higher, tripod foundations will become the dominant technology, which stand 45 to 60 meters tall (150 to 197 ft). As such, more than 200 feet overhead clearance will be needed to accommodate shipping these structures upright.

Outbound Logistics establishes the following requirements:

- Minimum overhead clearance of 150 feet, target 200 feet, ideally no overhead restrictions
- Minimum horizontal clearance of 450 feet, ideally greater than 500 feet

Table 3 - Port Infrastructure Requirements

Port Infrastructure Requirements
<ul style="list-style-type: none">▪ Minimum shipping channel and portside depth of 24 ft at low tide▪ Two berths, each at minimum berth length of 450 feet▪ Berths parallel to the port land area, or with wide peers minimum 98 feet wide▪ Crane capable of lifting at least 1,000 tons▪ Dockside transportation lanes at least 98 feet wide to accommodate crawler cranes and other logistics▪ 200 Total Acres

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- 60 acres at the dockside for Unloading and Loading, Staging, Transportation, and Assembly
- 30 acres adjacent to dockside area for lay down storage
- 100 acres additional space for onsite operations
- Minimum overhead clearance 150 feet, target 200 feet, and ideally no overhead restrictions
- Minimum horizontal clearance 450 feet, ideally greater than 500 feet
- Proximity to offshore projects

The pictures below illustrate the 200 hectare (approximately 500 acre) Bremen Offshore Wind Industrial Complex. It contains an offshore terminal and industrial park to facilitate all the offshore development activities from turbine assembly, foundation fabrication, other component manufacture and the services required to support the offshore wind projects during and post construction. This port is the benchmark for future offshore port activities.

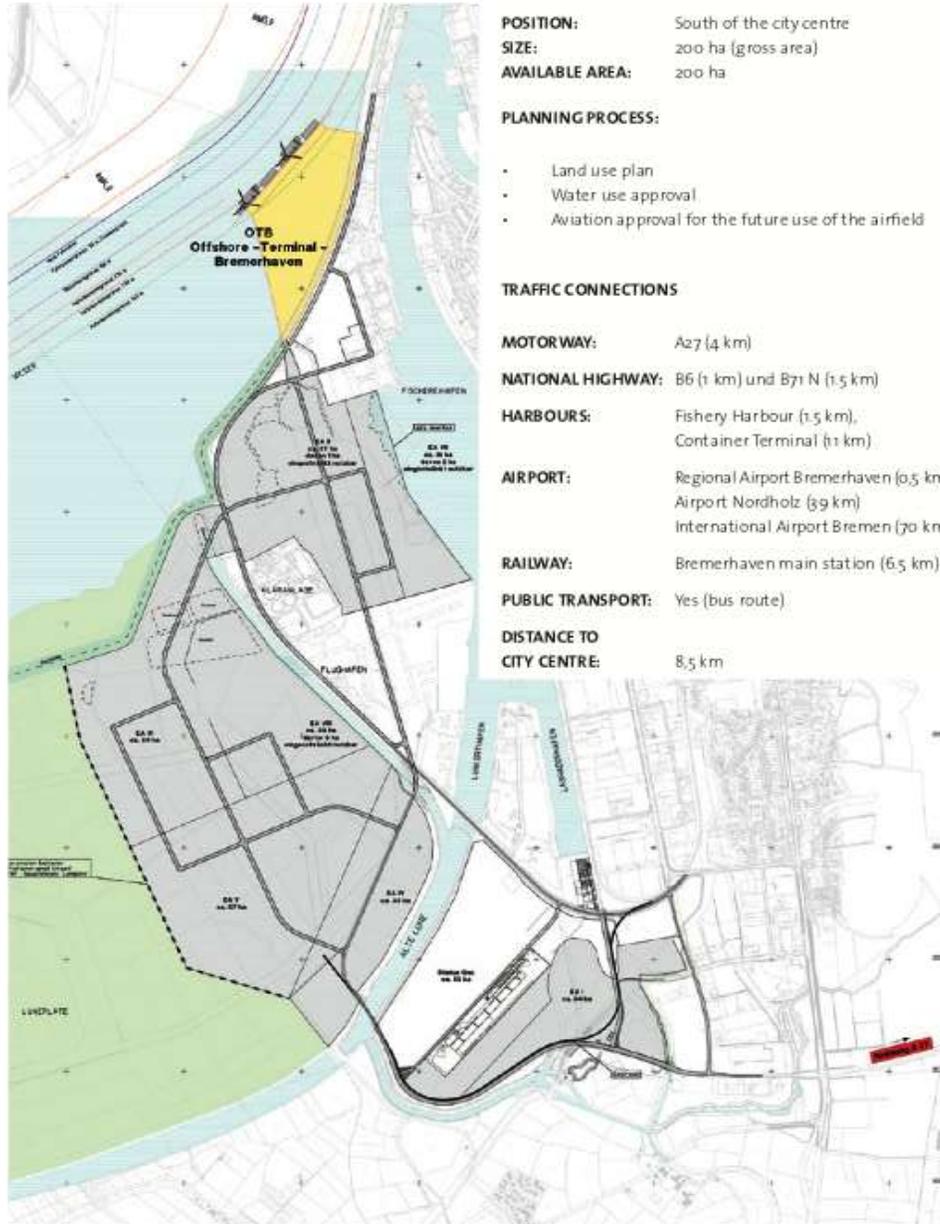
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The Lunepate industrial zone with 200 ha of expansion area is situated in the direct vicinity of the planned Offshore Terminal and the existing production facilities of the offshore industry

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Vessels

Jones Act

The Merchant Marine Act of 1920, commonly known as the Jones Act, requires vessels engaged in the transport of passengers or cargo between US places to be built and flagged in the United States, and owned and crewed by US citizens.

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Vessels with bottom-fixed foundations within the United States will be subject to the Jones Act, however, vessels which are used to transport turbine components from overseas to a US staging port are not subject to the Jones Act. Thus, cargo and delivery vessels may be owned/operated/flown under flags of non-US origin.

In Europe, offshore wind manufacturers and contractors prefer to use purpose-built vessels. However, these vessels are not currently available in the US, nor are they expected to be available by the time the first offshore projects begin installation. Construction costs for these vessels range from \$40-\$80 million for specialty-designed tug vessels, and \$150-\$250 million for self-propelled vessels. There are non-optimal substitutes available for use in the US, though, such as jack-up vessels used in the oil-platform industry, but their use could take more installation time than custom-built vessels and thus could increase installation costs.

Currently, there are no offshore wind energy purpose-built vessels available in the United States. Vessels which are compliant with the Jones Act but serve other offshore industries operating in the Gulf of Mexico could be used to construct the first-generation US offshore wind farms. These vessels lack the efficient, optimized features found in wind turbine installation vessels: the ability to transport multiple turbine sets/components, the ability to rapidly jack up, pre-load the legs, erect the turbines and jack down. In order to economically meet projected offshore wind demand in the US, a fleet of purpose-built, Jones-Act-compliant vessels will be required.

Vessels necessary for the installation of offshore wind turbines in generally fall into four activity categories:

Table 4- Installation Vessel Activities

Activity Type	Vessel needs
Turbine import/Delivery	Large open-hatch cargo vessel
Foundation delivery and installation	Jack-up crane vessel or floating derrick barge
Wind Turbine Installation	Leg-stabilized jack-up crane ships, jack-up crane barges, jack-up crane ships
Maintenance	Crew boats

Early offshore turbine installations will most likely be sourced from Europe until manufacturing of offshore turbines has been established in the US. Thus there will be large vessel transport needs for the disassembled components, most likely in open hatch cargo vessels.

Vessel Types

Import/Transport Vessels

Import vessels will only be subject to spatial requirements: length, beam and draft. Depending on the design of the wind turbine itself, the specifications necessary to transport or import disassembled components can be up to 470 ft length, 75 ft beam, 32 ft draft.

Low draft Barges

Low-draft barges are ideally suited to perform structure-to-shore pipeline and cabling investigations. However, high ocean currents cause instability which will dictate the use of tugboats for power.

Jack-up vessels

Jack-up rigs provide a stable working platform; however, expensive daily rates (e.g. up to \$150K per day) and significant support requirements can reduce their cost-effectiveness. They are typically used for oilfield activities.

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Figure 3: Jack up barge

Offshore wind turbine foundations are usually installed by floating crane vessels or mobile jack-up units, the choice of which is dependent on water depth, crane capability, and vessel availability. When using a crane vessel, it must be capable of lifting hook heights greater than the height of the rotor-nacelle assembly of the turbine. Some of the lift capacities, along with other equipment specifications, are summarized below. In shallow waters, conventional mobile jack-up rigs are typical, whereas for deeper waters, the floating crane vessels are usually deployed.

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Figure 4: Jack-up vessel

Table 5 - Vessel Specifications

Typical Installation Vessel Specifications			
VESSEL	VESSEL SIZE	GROSS TONNAGE	LIFT CAPACITY/ HEIGHT
Floating Crane Vessels			
Smit Land LM Balder	110m 30m 7.6m	7772t	500t / 60m
Smit Tak Taklift 4	83m 35m 7.0m	4854t	2400t / 75m
Smit Tak Taklift 7	73m 30m 5.5m	3513t	1200t / 65m
Bugsier Thor	76m 24m 4.7m	2667t	350t / 80m
Uglarid Uglen	78m 26m 4.3m	1589t	600t / 75m
Jackup Vessels with integral crane			
Ballast Nedam Buzzard	43m 3Dm 4.2m	1750t	198t / 62m
Interbeton 1B909	43m 3Dm 4.4rn	1796t	272t / 57m
Amec Wyslift	38m 32m 4.4m	1410t	280t / 50m
Seacore Deep Diver	3Dm 2Dm 4.5m	1675t	50t / 51m
Source: Geotechnical Considerations for Offshore Wind Turbines, Westgate/ DeJong 2005			

Crane Requirements

The type of turbine can have a significant effect on the capabilities of available installation cranes. Depending on nameplate capacity, nacelles can weigh between 140 and 320 tons, and monopiles can weigh up to 500 tons.



Figure 5 Jack-up crane barge. A2SEA's vessel, the Sea Jack

Foundation Installation

Foundations can be installed using either jack up crane vessels or floating derrick barges. Large floating derrick barges are in service on all three major US coastlines and could be mobilized to serve the US East Coast offshore wind energy market.

Depending on the foundation type (monopile, gravity base, jacket, tripod), a derrick barge could transport foundations between the staging port and wind farm site on its own deck or foundations could be transported using a separate barge. These barges have capacities up to 1, 000 tons, but a more common lifting capacity is 500 tons or less.

Availability

Declining US shipyard activity has created a capacity issue due to regulatory restrictions such as the Jones Act. As the number of available yards decrease, the availability of yards able to meet these requirements also decreases. This is particularly acute on the US East Coast.

Table 6 - Vessel Production

Nine Year Tug and Barge Construction Demand – US Shipyards											
Vessel Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	Totals	Average /Year
Tugs and	72	63	73	60	73	70	94	121	165	791	88

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Towboats											
Dry Cargo											
Barges >5000	1	3	2	0	4	1	3	2	4	20	2
Gross Tons											
Inland Dry Cargo Barges	775	609	672	217	427	219	672	846		4427	553
Source: MARAD Shipbuilding Statistics											

In addition, specialized wind farm vessels have unique construction and servicing requirements which would be subject to the constraint of increasing construction demand for more common tugs and barges due to increasingly strict regulations and replacement requirements.

Shipyard Availability

There are currently 4 large, active shipbuilding yards on the US East Coast: Bath Iron Works Corporation in Bath, ME; Electric Boat Corporation in Groton, CT; Kvaerner Philadelphia Shipyard, Inc. in Philadelphia, PA; and Northrop Grumman Newport News in Newport News, VA. There are 25 additional repair yards on the East Coast, with 1 topside repair yard residing in Maryland, the General Ship Repair Corporation of Baltimore, MD. The number of shipyards that have current capacity for large specialty vessel construction is limited within the United States. Thus, depending on the expected ramp-up in US offshore wind installation demand, it is highly likely that large vessel construction and small vessel construction would be most likely handled by multiple and different yards, specifically on the Atlantic and Gulf Coasts.

Capacity and Delivery

Orders for vessels average 6 to 12 months lead time to enter a construction cycle, however there are several smaller yards in the Northeast and Gulf that have no backlog, but are limited to smaller vessels. Few have multiple vessel capacity.

Atlantic Offshore Projects

There are a total of 15 projects, totaling 6,433 MW in different stages of development in the Atlantic. Of those projects four are active, with a projected capacity of 1,298 MW, two are under limited leases with approximate 700 MW and there are nine proposed projects with an additional capacity of 4,437 MW. The table below shows all the projects proposed in the US and the map below locates the Atlantic project locations.

Table 7 – US Offshore Wind Projects

<u>Developer</u>	<u>Project</u>	<u>Project Status</u>	<u>Region</u>	<u>State</u>	<u>MW</u>
ScandiaWind	Aegir Project	Proposed	Great Lakes	Michigan	500
Bluewater Wind NRG Energy	NRG Bluewater Wind New Jersey	Limited Lease	Atlantic	New Jersey	348
Bluewater Wind NRG Energy	Mid-Atlantic Park	Cancelled	Atlantic	Delaware	450
Baryonyx Corporation	Mustang Island	Land Lease	Gulf of Mexico	Texas	1,000
Baryonyx Corporation	Rio Grande North and South	Land Lease	Gulf of Mexico	Texas	1,000
Cape Wind	Cape Wind	Active	Atlantic	Massachusetts	468

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<u>Developer</u>	<u>Project</u>	<u>Project Status</u>	<u>Region</u>	<u>State</u>	<u>MW</u>
Deepwater Wind (Winergy)	Winergy Jones Beach	Proposed	Atlantic	New York	940
Deepwater Wind (Winergy)	Winergy South Long Island	Proposed	Atlantic	New York	300
Deepwater Wind (Winergy)	Block Island	Active	Atlantic	Rhode Island	30
Deepwater Wind (Winergy)	Deepwater Wind Energy Center (DWEC)	Proposed	Atlantic	Rhode Island	1,000
Deepwater Wind (Winergy)	Garden State Offshore Energy	Active	Atlantic	New Jersey	350
Delsea Energy	Newport Nearshore Windpark	Proposed	Atlantic	New Jersey	382
Fishermen's Energy	Fisherman's Energy New Jersey	Limited Lease	Atlantic	New Jersey	350
Hull	Hull Offshore Wind	Proposed	Atlantic	Massachusetts	15
Apex	Cape Lookout Energy Preserve	Proposed	Atlantic	North Carolina	450
Apex	Hampton Roads Offshore Wind	Proposed	Atlantic	Virginia	450
Apex	Maryland Offshore Wind	Proposed	Atlantic	Maryland	450
Apex	Lake Erie Offshore Wind Project	Proposed	Great Lakes	New York	500
Principle Power	Tillamook County Offshore Wind	Proposed	West	Oregon	150
Wind Energy Systems Technologies (WEST)	Galveston Offshore Wind	Proposed	Gulf of Mexico	Texas	300

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Maryland and Mid-Atlantic Port Infrastructure assessment

Regional Port Analysis

Evaluation of regional ports

Kinetik Partners has identified five high potential ports, either in or close to Maryland, which can participate in the establishment of the offshore wind supply chain. Those located outside of Maryland are considered competitive threats to the establishment of a Maryland presence in the offshore wind value chain. The ports are: Sparrows Point Industrial Complex, Dundalk Marine Terminal at the Port of Baltimore, Portsmouth Marine Terminal at the Port of Virginia, the port of Quonset, RI, and the Port of Wilmington, DE. Many terminals and ports were evaluated and a graphical representation of their analysis is below:

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Table 8 - Port Qualifications

	Port Characteristics											
	Acreage	Draft	Orientation/Width	Berth Length	Air Draft	Crane Capacity	Rail Access	Highway Access	Warehouse Capacity	Current Readiness	Potential Readiness	
T e r m i n a l s	Sparrows Point Industrial Complex	●	●	○	●	●	●	●	●	●	●	●
	Salisbury, MD	○	○	○	○	●	○	○	○	○	○	○
	Seagirt Marine Terminal	●	●	●	●	●	●	●	●	○	●	●
	Dundalk Marine Terminal	●	●	●	●	●	●	●	●	●	●	●
	Masonville Terminal (Fairfield)	●	●	●	●	●	○	●	○	○	○	○
	South Locust Point Marine Terminal	●	●	●	●	●	●	●	●	●	●	●
	North Locust Point Marine Terminal	○	●	○	●	●	○	●	○	●	○	○
	Container Transfer Facility	○	●	○	●	●	○	●	○	○	○	○
	Sparrows Point - Kinder Morgan Industries, Pier No. 1.	●	●	○	●	●	●	●	○	●	●	●
	Rukert Terminals Corporation	●	●	●	●	●	●	●	●	●	●	●
	Commodities Terminal Inc	●	●	○	●	●	○	○	○	●	○	○
	Quonset Business Park	○	●	●	●	●	○	●	●	●	●	●
	Wilmington, DE	○	●	●	●	●	○	●	●	○	○	○
	Va Port Authority	●	●	●	●	●	○	●	●	●	●	●
	Paulsboro, NJ	●	●	○	○	●	○	○	●	○	○	○

We will discuss in detail the high potential ports below.

Sparrows Point Shipyard Industrial Complex, Maryland

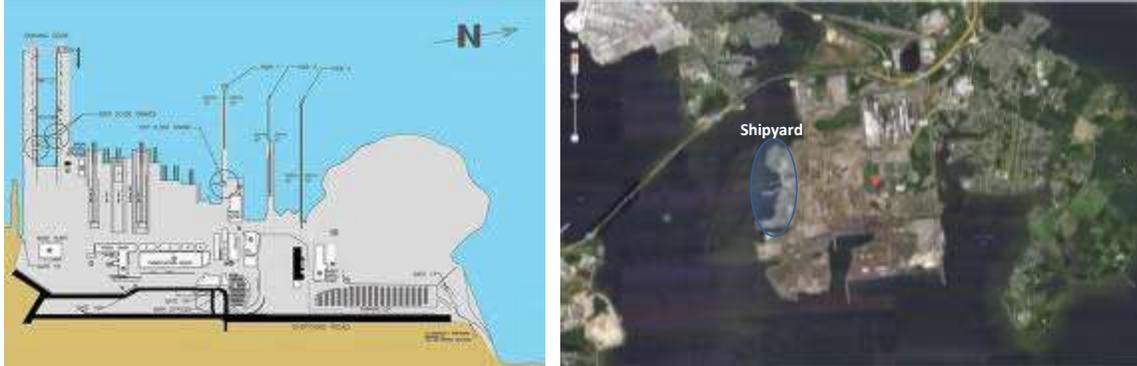
Overview

Sparrows Point is an approximately 2,300 acre industrial complex near Baltimore, Maryland which was home to Bethlehem Steel and Bethlehem Shipyards. The steel mill, at its peak in the 1950s, was the largest in the world. The shipyards were some of the most active in the US in the 1940s. After declining through the 1970s and 1980s due to rising competition from imports and newer technology furnaces, Bethlehem Steel suffered financial difficulty in the 1990s and filed for bankruptcy in 2001. After a number of ownership changes, the facility was acquired by RG Steel. The shipyard, a 250 acre facility at the southeast corner of Sparrows Point, has gone through a similar decline and currently does not have ongoing operations. The

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shipyard is now named Sparrows Point Shipyard Industrial Complex (SPSIC) and is actively being marketed for redevelopment. It has one of the largest graving docks in the US, which is capable of hosting the construction of super-tankers. There is an active effort to revive shipbuilding on at least part of this facility. We have analyzed the Sparrows Point Shipyard Industrial Complex for its potential as an offshore wind staging port.



Acreage

The SPSIC site totals 250 acres. We assume that the entire site is suitably convertible for an offshore wind farm staging port. The site has an undeveloped area with over 50 acres available space called North Yard. This site is at the northern end of the facility, opposite the graving dock and adjacent to the three piers. North Yard would suit well for assembly and storage. There is an area in front of the graving dock extending north approximately 20 acres that could be used for staging. Together, with roughly 150 ft on either side of the 1,200 ft long graving dock, the staging area should be adequate. Considering the port at Bremerhaven, it suggests 60 acres should be available at the dockside for unloading, loading, staging, and transporting components. Tetra Tech research calls for 10 acres minimum.

available, one at the graving dock and one at Pier 1, but the second berth may not be useful for loading or unloading components.

Berth Orientation

It is advantageous for the berths to be oriented parallel to the facility, making it easier to load and unload heavy components. This is the case for modern container vessels docking and also is the direction for ship berths at current staging ports for offshore wind farms. The SPSIC docks are perpendicular to the port, and while the graving dock has wide sides at 150 ft, Pier 1 at 60 ft wide is not wide enough to properly support offshore wind farm staging, loading and unloading without significant adaptation.

Air Draft for shipping lanes

There are two routes to get from Sparrows Point to the Atlantic Ocean. The shortest route is via the Chesapeake and Delaware Canal; minimum air draft for this route is 133 feet under the St. George's Bridge. An alternate route is south through the Chesapeake Bay with 185 ft of clearance under the Francis Scott Key Bridge. Detailed analysis follows in the subsection "The Route to the Atlantic".

Crane Capacity

The graving dock currently has two fixed 200 ton cranes at dockside. Considering the lift needs for current 3 – 4 MW offshore wind systems, this port capable. Crane upgrades would be necessary for lifting the components for 5+ MW wind systems.

Rail Access

Sparrows Point Shipyard Industrial Complex has ready access to rail service with a rail line running the length of the east side of the facility.

Highway Access

Sparrows Point Shipyard Industrial Complex has ready access to highways with two access points: Maryland Route 158 and Maryland Route 151. Both come directly out of SPSIC and meet up with Interstate 695 within 2 miles.

Warehouse Availability

SPSIC has approximately 350,000 square ft of industrial building space available across 8 buildings. Building sizes range from 100,000 square ft to 20,000 square ft.

Current Readiness

SPSIC currently has medium capability, limited by the availability of berths suitable for unloading and loading heavy cargo for offshore wind farms. General preparedness of the facility could be a concern due to its period of low utilization and idleness.

Potential Readiness

SPSIC has the potential to achieve the highest capability for offshore development ports, but will require significant investment. The berthing areas are not ideal, since there are not two 450 ft berths that align parallel to the facility. The facility is under some disrepair owing to its period of inactivity. SPSIC has the unique opportunity to be linked to an offshore steel cluster at the same facility. The greater facility has the ability to be a semi-vertically integrated hub for making large steel components for offshore wind farms, staging the offshore project construction, and hosting an offshore wind cluster on the greater industrial complex like Bremerhaven.

Dundalk Marine Terminal

Overview

With 13 berths, nine container cranes and direct rail access, the 570-acre (230 ha) Dundalk Marine Terminal, owned and operated by the Maryland Port Administration (MPA), remains the largest and most versatile general cargo facility at the Port of Baltimore.

Dundalk Marine Terminal has historically handled containers, breakbulk, wood pulp, ro/ro (roll on/roll off, as opposed to cargo that must be lifted on and off), autos (it is one of the top 3 auto handling ports in the US), project cargo, farm and construction equipment. Its breakbulk experience qualifies it as a potential fit for the handling of offshore wind turbine components. It has nine 40-long-ton (40.6 mt) container cranes and ten sheds totaling 789,820 sq. ft.; the port of Baltimore invested \$21 million on crane upgrades at Dundalk.

It has overall 370 acres of outside storage currently partitioned by type of cargo as follows: 105 acres (42.4 ha) container storage; 20.1 acres (8.1 ha) breakbulk storage; 152 acres (61.6 ha) automobile storage; 93 acres (37.6 ha) ro/ro. Norfolk Southern provides direct rail access to all berths and sheds. Two rail storage yards total 9,300 ft. of track. It has two 2,000 ft. storage tracks and five unloading tracks, ranging from 1,500 to 1,800 ft. It is 2.5 miles from I-95 and 1.5 miles from I-695 with easy access to other major interstates.

Dundalk recently signed a 20 year, 150 acre agreement to serve as the East Coast hub for the largest ro/ro carrier in the world, Wallenius Wilhelmsen. According to the MPA, there is sufficient space available at the facility that can be used as the first point of rest for materials or components being shipped from suppliers, both internal and external to Maryland. However, because Dundalk is active for other maritime uses, a limited amount of space would most likely be available. Even a small 120 acre offshore wind farm port operation would utilize 21% of Dundalk land area, representing a likely constraint on long term development of offshore wind operations at the terminal.

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Acreage

Dundalk Marine Terminal has ample space: 570 acres. Its outside storage is partitioned as follows: 105 acres container storage; 20.1 acres break-bulk storage; 152 acres automobile storage; 93 acres ro/ro.

Draft

Terminal draft is 34 ft. at four berths, 42 ft. at seven berths, and 45 ft. at two berths.

Berth Length and Number

13 berths total, with 600 ft length at six berths, 700 ft length at 4 berths, and 900 ft length at 3 berths. This terminal has fully capable berths, provided that two are available for offshore wind port operations.

Berth Orientation

The Berths are all oriented parallel to the terminal, which is advantageous for loading and unloading wind turbine cargo.

Air Draft for shipping lanes

There are two routes to get from Dundalk Marine Terminal to the Atlantic Ocean. The shortest route is via the Chesapeake and Delaware Canal; minimum air draft for this route is 133 feet under the St George's Bridge. An alternate route is south through the Chesapeake Bay with 185 ft of clearance under the Francis Scott Key Bridge. Detailed analysis follows in the subsection "the Route to the Atlantic".

Crane Capacity

Dundalk Terminal has nine 40-long-ton container cranes and a 250 ton truck crane. The truck crane can be available at any berth as needed and would provide capability for current technology wind components. Future larger machines would require an upgrade in crane capacity.

Rail Access

Norfolk Southern provides direct rail access to all berths and sheds. Two rail storage yards total 9,300 ft. of track. Two 2,000-ft. storage tracks and five unloading tracks range from 1,500 to 1,800 ft.

Highway Access

This port features ready access to highways 2.5 miles from I-95; 1.5 miles from I-695, and easy access to other major interstates.

Warehouse Availability

Ten sheds totaling 789,820 sq. ft.

Current Readiness

With the capabilities present at Dundalk, it has the capability to become an integral part of the offshore wind supply chain. Its ample internal and external storage, wide berths and optimal orientation for crane unloading of break-bulk cargoes are all good fits. Its access to rail and highway are positive characteristics as well.

We assume that Dundalk has available space to be used for offshore wind port operations. Given that Dundalk is a currently operating terminal, it may have to rearrange its agreements with current tenants in order to offer the best services for wind turbine assembly. Furthermore, the assumption that space is available will require additional validation.

Potential Readiness

Dundalk is an optimal early entrant in the offshore wind supply chain in Maryland. Given the likelihood that the early, immature supply chain will likely consist of imported components, it has the proper equipment to handle break-bulk, storage, warehousing, assembly of limited size components and launch. Dundalk would be an ideal short-term location and an ideal long-term partner in developing the proper port operations at a new location, such as SPSIC.

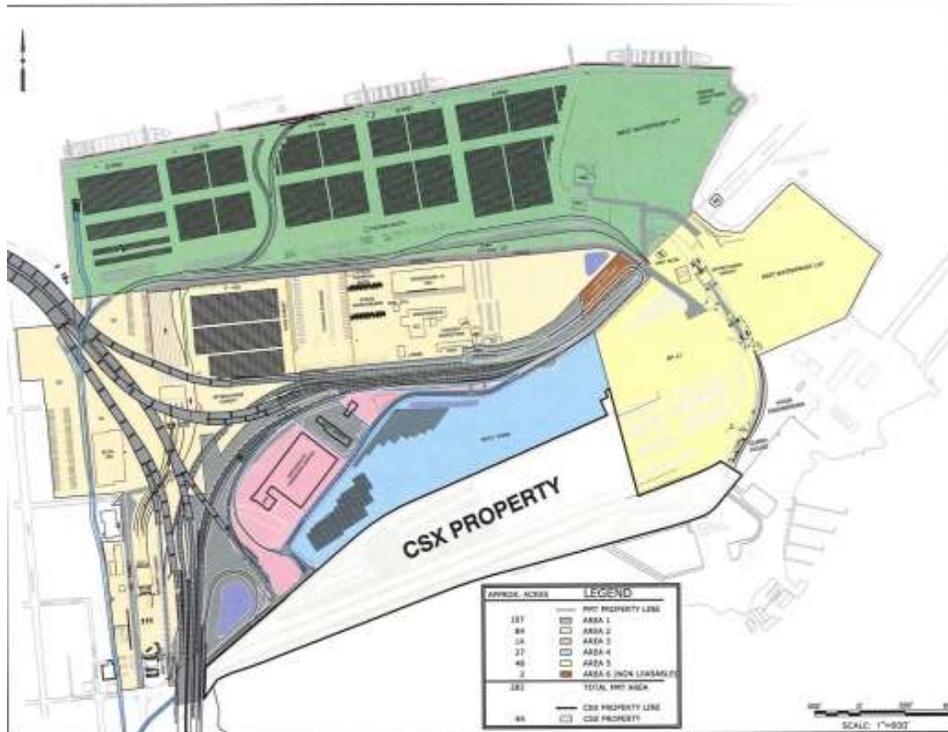
Portsmouth Marine Terminal, Port of Virginia

Overview

Portsmouth Marine Terminal (PMT) has a land area of 282 acres. It is located along the Elizabeth River at Pinner's Point in Portsmouth, Virginia. The terminal has a 45 foot-deep main channel and depth of 43 feet at wharf side. The terminal is serviced by 20,100 feet (6,100 m) of rail track, 9 cranes (one gantry crane directly on site). A 4,515 foot long wharf provides three berths for vessels carrying containerized, break-bulk and ro-ro cargoes. The terminal previously dedicated 188 acres to container storage space and has 84,500 sq. ft. of warehouse space. PMT is accessible via US Route 58, which is connected to Interstates 95, 64, and 664; and via rail serviced by Norfolk Southern Railway and CSX Transportation.



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The Virginia Port Authority recently shifted container operations away from PMT and is currently awaiting proposals for use or lease. There had been plans for a warehouse agreement with a paper and pulp distributor, but technical specifications regarding ground strength were not a proper fit. Wind turbine manufacturer Gamesa has issued a proposal to use 5 acres for operations related to the development of wind energy systems, which is regionally consistent with their recent establishment of a site in the Chesapeake developing prototypes with Newport News Shipbuilding.

Acreage

According to the map above, PMT has ample internal and external space for the development of large offshore wind farms. Areas 1 and 2 alone would be enough for operations, totaling 191 acres.

Draft

The port has capable dockside depth of 43 ft.

Berth Length and Number

A 4,515 ft long wharf provides three berths for vessels carrying containerized, break-bulk and roll on/roll off cargoes.

Berth Orientation

The berths are all oriented parallel to the port, which is advantageous for loading and unloading wind turbine cargo.

Air Draft for shipping lanes

No restrictions.

Crane Capacity

This port has crane capability: one gantry crane and the remainder are container cranes. Gantry cranes may be able to handle the heaviest loads, however it is likely they will require upgrades to handle foundations and offshore wind staging (much like several of the other ports reviewed). There are also no readily identifiable reasons why proper cranes could not be added to any port.

Rail Access

The terminal has on-site rail access provided by CSX.

Highway Access

The port has ready access to major interstates.

Warehouse Availability

Ample availability of 84,500 sq. ft. of warehouse space.

Current Readiness

The site is readily available to begin servicing the offshore wind industry. There are no obvious barriers to begin operations at this site.

Potential Readiness

Crane upgrades remain the only qualification, which could be required. Otherwise this site has the highest order of fit.

Port of Wilmington, Delaware

Overview

The Port of Wilmington is a 308 acre facility at north end of the state of Delaware at the intersection of the Delaware and Christina Rivers. It has seven deepwater general cargo berths, a tanker berth, a floating ro/ro berth for autos. The port of Wilmington has the nation's largest dockside cold storage capability.

There are already some wind related activities at the Port of Wilmington, as it has already been utilized as a turbine blade import location as early as 2001. The port handled inbound turbine blades for GE's onshore turbines more recently in 2009 and 2010. In addition, the port has teamed up with NRG Bluewater Energy to stage offshore wind projects from the port. The figure below is the proposed site plan for the development. The dark-blue shaded area at the lower left corner of the facility represents outside storage and is approximately 20 acres, while the yellow area indicates the wind project development site, approximately 130 acres. The port of Wilmington and NRG Bluewater applied for a federal stimulus grant under the TIGER program to upgrade the wharfs, but was turned down. In addition, NRG Bluewater has recently put its offshore development plans on hold.



Acreage

The proposed offshore wind project development site would have totaled 150 acres. The proximity to the docks is non-optimal. 20 available acres at the port facility is insufficient in addition to the fact that the area is not directly adjacent to the berths. If utilizing all the outside storage areas indicated above, perhaps 30 acres will be available on-port, but this remains insufficient.

Draft

The port of Delaware is a deepwater port with depths at dockside of 35-38 ft. This port is fully capable on depth.

Berth Length and Number

The port has six capable berths. The smallest berth is 382 feet, while the rest are 500 – 600 feet. The port is fully capable on berths.

Berth Orientation

The berths are all oriented parallel to the port, which is advantageous for loading and unloading wind turbine cargo.

Air Draft for shipping lanes

There is one bridge to traverse to gain access to the Atlantic Ocean from the port of Wilmington. The Delaware Memorial Bridge has 188 feet of vertical clearance for ships to pass beneath it. 188 feet of clearance is sufficient for current technology, but could become difficult to stage larger turbines, especially large machines which require tripod foundations (60 m/197 ft). If the industry practice moves to shipping fully assembled upright turbines on floating platforms from the staging port, then the clearance under the Delaware Memorial Bridge will jeopardize the port of Wilmington's ability to serve as an offshore wind staging port.



Source: route40.net

Crane Capacity

This port has basic heavy crane capability based on its experience receiving onshore wind turbine blades. Still, all ports will need to upgrade crane capability for offshore wind staging, so this is not a distinguishing feature. There are no readily identifiable reasons why proper cranes could not be added to any port.

Rail Access

The port of Wilmington has on-terminal class 1 rail service.

Highway Access

The port has ready access to major interstates.

Warehouse Availability

It is not clear if any warehousing is available, and based on the wind project site plan, we assume that no warehouse space is available, since none was highlighted. If a new wind development zone is breaks ground at the port, additional warehousing will likely be a part of that development.

Current Readiness

The port of Delaware lacks some critical characteristics to participate in offshore wind project staging. Most importantly, the site lacks proper land area until a new site is developed, and that land is not adjacent to the ship berths for offshore wind farm staging. There is no warehousing currently available.

Potential Readiness

Provided that the port upgrades its facilities by developing the 130 acre wind farm project site, the port could address the land area and warehousing shortcoming, but the issue of wind farm staging area proximity to ship berths will remain, unless the new area includes new ship berths.

Paulsboro NJ

Overview

The Inland Terminal maintains a wharf in Paulsboro primarily for the receipt of steel and other large cargoes. BP once occupied a terminal in Paulsboro which contained approximately 130 acres which is currently going under environmental remediation and redevelopment. It is expected to be operational by the end of 2012. Its redevelopment includes the removal of the fuel storage tanks. It is adjacent to the Delaware River, and is navigable by large oceangoing vessels. An 8-acre parcel to the northwest is occupied by a 22,000-square foot warehouse and a 1.5-acre yard currently leased to a marine spill emergency response company. There are an additional 23 acres to the southeast of the terminal. While there are no current operations or infrastructure on the site, it may have the ability to rapidly be developed to fit the needs of the offshore wind industry.

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(source: http://www.bpaulsboronj.com/paulsboro_terminal/aerialviews.html)

Acreage

It has approximately 130 acres available with adjacent acreage available.

Draft

Undeveloped.

Berth Length and Number

Undeveloped.

Berth Orientation

Undeveloped.

Air Draft for shipping lanes

No restrictions.

Crane Capacity

No cranes.

Rail Access

Undeveloped.

Highway Access

Close access to interstates network; under 2 miles.

Warehouse Availability

Adjacent 22,000 sq. ft. of space.

Current Readiness

Site is still under development, and is therefore not ready.

Potential Readiness

Given the size, adjacent warehouse and potential to customize the site, it would appear to have moderate potential to develop an offshore wind supply cluster.

Quonset Business Park, Rhode Island

Overview

Quonset Business Park is a 3,207 acre development project managed by Quonset Development Corporation, a division of the Rhode Island Economic Development Corporation. It is formed by the combination of the Quonset State Airport to the south, Port of Davisville to the north and commercial land stretching inland to the west. The airport and surrounding area was formerly the Naval Air Station Quonset, built during World War II, and decommissioned in 1974. Quonset Business Park lists 503 acres of parcels, with 255 acres available, 214 acres under agreement or option, and 33 acres occupied by the airport operating company.



Quonset is the offshore wind farm staging port for Deepwater Wind. Deepwater wind has leased 117 acres at Quonset Business Park for 10 years for \$20.7 million. In addition, the Quonset Development Corporation has secured a \$22.3 million federal TIGER grant to upgrade the structures of the two piers at the Port of Davisville. The Port of Davisville offers 4,500 linear feet of berthing space, consisting of two piers (each 1,200 ft in length), a bulkhead, 29 ft controlling depth - mean low water (MLW), on-dock rail and a 14 acre lay down area.

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Acreage

The secured acreage for Deepwater Wind is 117. Given the overall size of the facility, expansion to 200 acres is realistic. The stated lay down area at 14 acres at the portside will prove to be a challenge as turbine size grows and more land is needed around the port. No details are available for the layout and location of the 117 acres. With the given information for land area, this port is suitable for current industry needs and could likely be expanded to suit future needs. Of particular benefit is the large commercial park at this site, which allows this port the potential to expand to a full offshore wind cluster.

Draft

The Port of Davisville is a deepwater port with 29 ft of draft. This is sufficient for offshore wind port operations given the 24 ft draft requirement.

Berth Length and Number

This port has six berths, three at 1,200 ft, one at 650 ft and two at 250 ft. This port is fully capable on berths.

Berth Orientation

The berths are oriented perpendicular to the port, but the piers are quite large. Pier No. 1 is approximately 500 ft wide and Pier No. 2 is approximately 250 ft wide. Pier No. 2, at 250 ft wide, is capable for staging offshore wind projects, provided that the pier can withstand the weight of the components. The TIGER grant awarded to Quonset is specifically for upgrading the structures of both Piers No. 1 and 2.

Air Draft for shipping lanes

A ship calling on port of Davisville must pass under one of two bridges crossing Narragansett Bay, the Jamestown Verrazano Bridge or the Pell Newport Bridge. The Jamestown Verrazano Bridge has only 135 feet of clearance beneath, but the Pell Newport Bridge has 206 feet of clearance beneath.



Jamestown Verrazano Bridge

- Ship Clearance: 135 Feet
- Main Span Length: 600 Feet



Pell Newport Bridge

- Ship Clearance: 206 Feet
- Main Span Length: 1,600 Feet

206 feet of clearance is sufficient for current technology, but could become difficult to stage larger turbines, especially large machines which require tripod foundations reaching 60 meters (197 feet) tall. If the industry practice moves to shipping fully assembled upright turbines from the staging port, then the clearance under the Pell Newport Bridge will jeopardize Quonset Business Park's ability to serve as an offshore wind staging port.

Crane Capacity

This port does not have heavy lift cranes, but is installing one as part of the port upgrade to accommodate Deepwater Wind through the TIGER grant. After completion of the port upgrades, this port will be fully capable on crane capacity for at least current generation machines. The crane capacity can be upgraded at a future date to handle larger offshore wind components for 5+ MW machines.

Rail Access

The Port of Davisville at Quonset Business Park has onsite rail serving both piers.

Highway Access

The port has ready access to major interstates.

Warehouse Availability

Quonset Business Park lists 240,000 square feet of warehouse available, even after Deepwater Wind has leased its space. This port is fully capable on warehousing.

Current Readiness

The Port of Davisville at Quonset Business Park is becoming capable for current offshore wind technology, based on the establishment of operations for Deepwater Wind.

Potential Readiness

The availability of space directly adjacent to the port for staging may be limited in the future given the robust business in vehicle importing which takes up a great deal of space at dockside. In addition, bridge clearance may be insufficient to support shipping tripod foundations and fully assembled turbines in the future.

Route to the Atlantic

The extra logistics costs to stage wind turbines from the Baltimore area relative to other ports are negligible, despite the apparent geographic disadvantage. Both the port of Baltimore and SPSIC have logistics disadvantages when compared to other ports with direct access to the Atlantic, specifically 171 nautical miles (nm) of extra ocean transit through the Chesapeake Bay. The Chesapeake-Delaware Canal was meant to serve as a palliative short cut to northeast US destinations; however, its air draft constraints will not allow Chesapeake area ports to haul large wind-turbine

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sized equipment and vessels through the canal. Thus, vessels will be forced to go through the mouth of the Chesapeake.



The Chesapeake and Delaware Canal is shown in the map directly above and a summary of the six canal bridges with clearance is shown in the table below.



Chesapeake City Bridge

- Ship Clearance: 135 ft
- Main Span Length: 540 ft



Summit Bridge

- Ship Clearance: 135 ft
- Main Span Length: 600 ft



Rail Lift Bridge

- Ship Clearance: 138 ft (Raised)
- Main Span Length: 600 ft



Senator Roth Bridge

- Ship Clearance: 138 ft
- Main Span Length: 750 ft



St George's Bridge

- Ship Clearance: 133 ft
- Main Span Length: 540 ft



Reedy Point Bridge

- Ship Clearance: 134 ft
- Main Span Length: 600 ft

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The longer route to the Atlantic is south through the Chesapeake Bay. Through that route, there is only one vertical obstruction, under the Francis Scott Key Bridge, as shown in picture below. This bridge has a vertical clearance of 185 feet, and a horizontal clearance of 1,200 feet between piers.



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The Chesapeake and Delaware canal is almost unusable for transporting offshore wind components out to sea, given its low clearance. Jack-Up vessels have 150 feet of air draft, as do rotors in the bunny ear configuration. As turbine size grows, and water depths at offshore wind farms increase, so too will jack-up vessel air draft. Taller components such as tripods will threaten the viability of any port north of the Francis Scott Key Bridge. If industry practice moves to deepwater turbines fully assembled on floating platforms and shipped upright, which will likely exceed the clearance of the Francis Scott Key Bridge, then SPSIC and all Baltimore area terminals will not be capable of staging offshore wind farms. However, if the assembly practice remains partial assembly at the port with final assembly at sea, then SPSIC and near terminals will be highly qualified fits.

While the incremental distance through the mouth of the Chesapeake might seem like a large challenge to the establishment of Maryland as the premier launch pad to service the offshore wind industry, relative to the costs of installing an offshore wind farm, these incremental logistics costs are negligible. Table 9 illustrates this below:

Table 9

Baltimore Incremental Logistics Cost as a % of Total Installed Costs						
Destination						
	Nantucket Shoals		Atlantic City, NJ		Wilmington, NC	
	Low	High	Low	High	Low	High
Baltimore (via Chesapeake)	0.42%	1.69%	0.22%	0.89%	0.13%	0.52%

Table 10

Range of Values - Total Logistics Cost Differential from Different Departure Ports based on High/Low dayrate, # trips required (\$Millions)						
Destination						
	Nantucket Shoals		Atlantic City, NJ		Wilmington, NC	
	Low	High	Low	High	Low	High
Baltimore (via Chesapeake)	\$5.56	\$25.08	\$2.92	\$13.17	\$1.71	\$7.71

Proximity of port locations to proposed projects

Differential Analysis

In order to determine the fit of Maryland ports to service the offshore wind energy value chain, we conducted an incremental analysis relative to the best-case port for the three major Eastern Seaboard regions where offshore projects have been proposed. Using Nantucket Shoals, Atlantic City, NJ and Wilmington, NC as the proxies for offshore sites, we calculated the distance differentials based on Department of Commerce nautical charts. Thereafter, we developed cost ranges based on vessel day-rates, average vessel speed, vessel carrying capacity and types of turbines installed. Actual distances are tabulated below:

Table 11

		Destination (Distance nm)		
		Nantucket Shoals	Atlantic City, NJ	Wilmington, NC
Origin	Baltimore (via Chesapeake)	531	321	486
	Norfolk VA	408	198	363
	Providence, RI	131	220	412
	Wilmington, DE	347	111	554

The table below illustrates the incremental distance from each port relative to the installation site's closest port (represented by "0").

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Table 12

		Destination Differential from Closest (nm)		
Origin		Nantucket Shoals	Atlantic City, NJ	Wilmington, NC
	Baltimore (via Chesapeake)	400	210	123
	Norfolk VA	277	87	0
	Providence, RI	0	109	49
	Wilmington, DE	216	0	191

Based on different average travel speed, the incremental difference in days would manifest as below

Table 13

Low Cost/High Speed Scenario					High Cost/Low Speed Scenario				
		Destination Differential from Closest (Days)					Destination Differential from Closest (Days)		
Origin		Nantucket Shoals	Atlantic City, NJ	Wilmington, NC	Origin		Nantucket Shoals	Atlantic City, NJ	Wilmington, NC
	Baltimore (via	2.78	1.46	0.85		Baltimore (via	4.17	2.19	1.28
	Norfolk VA	1.92	0.60	0.00		Norfolk VA	2.89	0.91	0.00
	Providence, RI	0.00	0.76	0.34		Providence, RI	0.00	1.14	0.51
	Wilmington, DE	1.50	0.00	1.33		Wilmington, DE	2.25	0.00	1.99

We then calculated the low and high range of number of trips necessary to install a 500 MW wind farm and applied that toward the average cost and other assumptions, as illustrated below:

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Table 14

Assumptions		
	Low Cost Scenario	High Cost Scenario
Average Speed (nmph)	6	4
Average # Machines/Barge	5	3
Jack-up Dayrates	\$100,000	\$130,000
Wind Farm Nameplate Capacity (MW)	500	500
Turbine Nameplate Capacity	5	3.6
# Turbines	100	139
# Trips For Installation	20	46
Per Turbine Installation Cost (\$millions)*	\$13	\$11
Total Installation Costs (\$millions)*	\$1,321	\$1,480

*from Maryland Steel Suitability Analysis.

This results in the following range of incremental costs for deploying wind turbine equipment from any of the previously described ports, relative to the best-case port:

Table 15

Total Logistics Cost Differential Summary from Different Departure Ports based on High/Low day rate, # trips required (\$Millions)							
		Nantucket Shoals		Atlantic City, NJ		Wilmington, NC	
		Low	High	Low	High	Low	High
Origin	Baltimore (via Chesapeake)	\$5.56	\$25.08	\$2.92	\$13.17	\$1.71	\$7.71
	Norfolk, VA	\$3.85	\$17.37	\$1.21	\$5.45	\$0.00	\$0.00
	Providence, RI	\$0.00	\$0.00	\$1.51	\$6.83	\$0.68	\$3.07
	Wilmington, DE	\$3.00	\$13.54	\$0.00	\$0.00	\$2.65	\$11.97

As one can see, there are incremental costs staging from the Baltimore area, however as a percentage of total installed costs for an offshore wind farm, the costs are small and can possibly be made up by reduced inbound logistics by establishing an offshore wind capacity and innovation industrial cluster model, as well as process improvement, production efficiencies, higher speed boats, or larger haul vessels.

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Table 16

Logistics Cost Differential Summary as a % of Total Installed Costs							
		Nantucket Shoals		Atlantic City, NJ		Wilmington, NC	
		Low	High	Low	High	Low	High
Origin	Baltimore (via Chesapeake)	0.42%	1.69%	0.22%	0.89%	0.13%	0.52%
	Norfolk, VA	0.29%	1.17%	0.09%	0.37%	0.00%	0.00%
	Providence, RI	0.00%	0.00%	0.11%	0.46%	0.05%	0.21%
	Wilmington, DE	0.23%	0.92%	0.00%	0.00%	0.20%	0.81%

Port suitability for offshore deployment

What is the offshore wind opportunity for Maryland ports: How suitable are the ports? What is required to make them competitive?

Maryland state government and industry have taken positive steps to facilitate future clean technology industry growth, such as having an aggressive Renewable Portfolio Standard (RPS), engaging with key stakeholders – trade unions and employers – and studying the state’s capabilities to compete in a global industry. We reflect our views based on discussions with industry experts and our own proprietary analysis, along with a set of recommendations to leverage public and private support.

To capture long-term offshore wind project value for port operation, Kinetik Partners recommends that the state of Maryland engage with industry to catalyze the development and improvement of port infrastructure at Sparrows Point’s SPSIC. We propose a two-tiered strategy: a near-term tactical approach to establish operational momentum and a longer term cluster development strategic approach. For the near-term tactical approach, with execution over the next 1-3 years, we recommend seeking to locate port operations for an upcoming offshore wind park at Dundalk Marine Terminal or SPSIC, with Dundalk Marine Terminal being in a higher state of readiness. For the long term strategy beyond 3 years, we recommend establishing operations at SPSIC.

These two strategies are consistent with the two primary ways that port operations for offshore wind are developed: the developer based model and the industrial and innovation cluster based model for offshore wind farm port development.

Developer Based Model

A developer driven offshore wind port is characteristic of an emerging or early growth stage industry. Due to the fact that the supply chain and infrastructure are immature at this early industry stage, it is common that the developer must take the central role in coordinating all aspects of the supply chain, including some infrastructure development. A staging site for the offshore wind park is necessary, so the developers seek out existing ports with the best-suited infrastructure to serve as the staging and launching point for the offshore wind park construction. In this capacity, the developer is seeking the cheapest and fastest option, while meeting his requirements. There is little long-term thinking, since the developer pipeline may only be one or two projects, and as such, all associated port development costs must be attributed to this pipeline. Port administrations, local and state governments often become involved as well, seeking economic development for their region and constituents.

The majority of components in this model will be imported, since the regional supply chain is not yet developed. For developer-driven offshore port development, the two critical aspects of port selection are proximity to the project and suitability of current infrastructure (which can approximate cost to bring the port up to full capability). The developing offshore wind port at Quonset Point, Rhode Island is an example of developer driven port development. The proposed, but currently postponed, offshore wind port at the Port of Wilmington, Delaware, is also an example of developer driven port development. Overall, this model offers high value opportunities for business with minimal investment and limited switching cost for developers.

Capacity and Innovation Industrial Cluster Model

The cluster-based model for offshore wind development is characteristic of a late stage growth, or maturing, industry. In this model, strong regional planning and industry participation are the primary drivers for developing the cluster, including

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the port. The cluster goal is to build a self-reinforcing industrial center made up of growing local and regional suppliers which have entered the offshore wind supply chain along with global suppliers which have set up local or regional operations to serve the local and regional markets. The offshore wind cluster reduces logistics and integration costs across the supply chain due to the close proximity of co-located suppliers at different points of the value chain. Port activities are one critical segment of the offshore wind supply chain; and as the final launching point for projects, ports are logical geographic centers around which to organize a cluster, provided that the port has adequate proximity to the region's projects. This is a critical distinction; by consolidating the upstream supply chain and thereby reducing the inbound costs, an offshore wind cluster can extend the range of projects it serves compared to project developer driven port development.

The cluster can be thought of as an analogue to vertical integration. Several successive links in the value chain locate together to take advantage of reduced logistics costs and easy sharing of knowledge between suppliers whose adjacent outputs come together into the same end product. In contrast to vertical integration, the related links in the value chain are represented by several companies rather than one company. Also, a successful cluster derives benefits from network effects – the more participants in a network, the more valuable it is. Therefore, it is advantageous for competitors to co-locate in the cluster to take advantage of the available inputs, knowledge and logistics efficiencies.

The region of Bremen, Germany has been extremely successful at building a strong regional cluster formed by over 350 companies. These companies, with the support and funding of the regional government, have developed an offshore cluster which is further strengthened by the development of a state of the art offshore port and associated industrial complex. The cluster organization has been able to develop regional capabilities to support the complete spectrum of supply chain serving the offshore industry: R&D, heavy fabrication, blade manufacturing, turbine OEMs, service and logistics companies.

The port of Bremen has been successful securing high profile companies to open operations within their complex: two OEMs – Areva Wind GmbH and Repower Systems AG, an offshore construction company – WeserWind GmbH Offshore Construction Georgsmarienhütte, and a blade manufacturer – PowerBlades GmbH, in addition to others. Bremerhaven is growing this cluster by developing specialized offshore infrastructure and making substantial land available (450 acres) for the expansion of the supply base located at Bremerhaven complex.

Project Developer Based Port Development for Maryland

Dundalk Marine Terminal

Our analysis of the port operations in Maryland has identified two primary areas in Maryland that Kinetik Partners recommends for detailed study of development potential for offshore wind in the near term over the next 1-3 years. The first area, the Dundalk Marine Terminal, is an optimal early entrant for the offshore wind supply chain in Maryland. Given that the current supply chain in the US is immature for offshore wind turbine components, it will consist of imported components. Dundalk has the proper equipment to handle break bulk cargo, which is the type of cargo represented by offshore wind components, reinforced by its 250 ton crane already at port. This crane will handle all components for current, 3-4 MW turbines. Upgrades would need to be made for offshore wind farms employing larger, 5+ MW turbines. Dundalk also has the capability for storage, warehousing, assembly of limited size components and launch. However, this is incumbent upon sufficient area being available. Dundalk is currently an operating terminal, which means that sufficient free space may not be available. Kinetik Partners is recommending 200 acres minimum for port operations, with the assumption that over the medium to long term, successful ports will need to develop into an offshore wind cluster. With NRG Bluewater leasing 117 acres at Quonset, this land area can be considered a lower bound of short-term feasibility for offshore wind port operations. 117 acres would represent just over 20% of available land area at Dundalk.

Sparrows Point

The second area identified is the Sparrows Point Shipyard Industrial Complex (SPSIC), the former Bethlehem Shipyards at the southwest corner of the larger Sparrows Point land area. This area has some critical assets that make it attractive for offshore wind development staging in the near future and over the long term. Its ample land area is a critical asset for offshore wind port development, as well as well as a positive economic development opportunity to convert a brownfield facility into a clean energy facility. The SPSIC totals 250 acres and is fully available. Depth of port and berths available is another critical consideration. The graving dock provides at least one berth and Pier 1 may provide a second berth. The twin 200 ton cranes at the graving dock provide sufficient lifting capability to handle current generation offshore turbines. The number of berths currently suitable for offshore projects will limit this facility, as well as the ramp up of its basic capabilities after years of limited activity. However, over the medium to longer term, these limitations can be overcome with some investment. With SPSIC residing on a larger 2,300 acre under-utilized facility, the potential space for development far exceeds any large-scale cluster that could be developed.

The advantages of setting up short-term offshore wind port operations are three fold. First, it presents the opportunity to gain early knowledge and expertise for handling offshore wind turbine components and staging offshore wind projects. Second, it places critical members of the supply chain onsite. Once a turbine company is selected for the project by the developer, it can place up to 15 personnel onsite to manage the handling and assembly of their company's products. Similarly, other critical supply chain companies will locate their personnel onsite for portions of the project development – the developer, gearbox manufacturer, tower supplier, foundation supplier, blade manufacturer, etc. Third, the first two points of experience will help to form the foundation for a long-term-focused cluster. With the first two activities comes critical knowledge transfer; some local firms and personnel will learn how to participate in the offshore wind supply chain as they work alongside the more experienced, outside companies. The outside companies

will become experienced and gain a level of comfort with the state of Maryland, the Baltimore area, the capabilities of local firms and the effects of the Baltimore location on their business. This experience and the relationships formed during this short-term operation can be directly transferred to building a long-term offshore wind supply chain cluster.

Cluster Based Port Development for Maryland

Maryland has the unique and substantial opportunity to help build two to three interrelated clusters focused on offshore wind. A port-based cluster will integrate suppliers of large components – nacelle, rotor blades, foundations, and towers – together with port infrastructure, and port and offshore service companies – logistics providers, vessel operators, and offshore construction firms. A steel manufacturing cluster for foundations, tower segments, and nacelle structural castings is highly valuable and is the subject of another report by Kinetik Partners for the Maryland Energy Administration. The overlap with the port cluster shows the integrative nature of clusters along the supply chain. A third potential cluster is shipbuilding, since the Jones Act requires vessels working in US waters to be built and flagged in the US and crewed by US personnel. With this requirement, the lack of offshore wind-specific vessels operating in the US and the larger expected market, there is opportunity in offshore vessel construction. However, shipbuilding is beyond the scope of this report.

A cluster based development for offshore wind port development in Maryland needs to be an integrated public private partnership which works on critical portions across the entire offshore wind value chain. Key driving participants in this partnership include the Maryland Department of Business & Economic Development, the Maryland Energy Administration and local businesses. In addition, this base should actively seek to attract and involve new businesses with skills and experience in offshore wind that are not represented among the local base of industry. Since renewable energy is a regulatory driven market, it will be necessary to leverage the state's delegation to the US Congress, the General Assembly and the state Governor.

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We recommend that the state of Maryland pursue the following portions of the supply chain to develop the offshore wind port cluster: wind turbine OEMs; rotor blade manufacturers; steel suppliers for foundations, towers and large castings (covered in another Kinetik Partners Report to Maryland Energy Administration); offshore wind construction companies. In addition, it can reinforce the cluster with development facilities focused on the deployment of very large turbines on site.

Cluster Location

Kinetik Partners' analysis shows that the Sparrows Point Shipyard Industrial Complex is an excellent candidate for developing an offshore wind cluster with port operations for launching offshore projects. It has the area needed, some existing port infrastructure to build from and all other necessary infrastructure requirements. It has some current limitations due to the facility sitting idle and the associated general degradation of the facility, however its suitable berth availability and orientation to the port are of the highest fit.

In addition to the basic infrastructure requirements for an offshore wind port, Sparrows Point has the very unique opportunity to co-locate a port cluster with a heavy steel component-manufacturing cluster. It is possible to co-locate offshore vessel shipbuilding operations at the site as well. By combining the port operations with OEMs and their critical suppliers, including heavy steel manufacturing, at one site, Maryland can overcome its location-based disadvantages (based on distance to projects compared to other potential port sites), and become the leading site for offshore wind in the Eastern United States. The port at Bremerhaven provides an excellent example of the value of collocating these activities and therefore consolidating the logistics of offshore wind farm construction.

OEMs

OEMs are a critical link for an offshore wind port cluster. After developers select locations and get the permitting and detailed site study process underway, the next task is to select a partner OEM. OEMs design and specify entire wind systems, from

drivetrain architecture and rotor blade shapes to foundation and tower requirements. Additionally, OEMs select suppliers for these critical pieces. OEMs control or heavily influence approximately 50% of the entire value of a wind farm (Turbine 26% + Balance of Plant 27%).⁶ Market leaders are currently Siemens and Vestas with their 3.6 MW and 3.0 MW machines respectively, with Gamesa, Alstom, and Areva coming to market in the next 12 to 24 months with newer, bigger, cheaper (per MW installed and per kWh cost of energy produced) 5+ MW machines. These are the companies that should be targeted for attraction to an offshore wind port development.

Development Site

Turbine development is a critical portion of the supply chain, especially activities immediately preceding the introduction of new turbines. Some large offshore ports are providing OEMs the opportunity to deploy a limited number of machines directly on site and then purchase the electricity for internal consumption.

As part of an offshore wind port cluster at Sparrows Point, we recommend facilitating the installation of multiple test beds both onshore and offshore in shallow water for turbines in the range from 5-7 MW. The turbine test sites could be located on the Sparrows Point campus and nearby in the Chesapeake Bay for additional validation in an offshore environment, in addition to supplying power into the RG Steel campus. The ability to test the turbines in a controlled manner at low risk and cost to deploy offshore is of high value to OEMs.

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This provides value to the region in multiple ways: it can establish close relationships with OEMs and it allows for service companies to move rapidly up the installation, maintenance and machine operation learning curves.

These sites can be provided within the SPSIC either on land or in the water. The pictures above show the installation of a Bard 5 MW machine on a German harbor (left) and an Areva M5000 on the assembly plant (right).

Further Study

Other geographical areas within Maryland, such as the Eastern Shore and Tidewater areas, could also present favorable locations to develop port and cluster operations. The town of Cambridge, for example, contains Maryland's second-largest deepwater port and is located 74 miles from the Port of Baltimore's 50-foot channel. It is also outside of any air draft-constrained areas. Other areas which could be investigated

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further are Maryland's Atlantic Coast near Ocean City, due to its accessibility to open ocean. However, these sites are farther away from embedded industrial capabilities and may not present the optimal economic benefit to the state; but these sites may be able to offer services or supply specific portions of the offshore wind value chain as it develops in Maryland.

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About this study

Kinetik Partners conducted this independent study for the Maryland Energy Administration. The information and analysis presented on this document is based on public information and on Kinetik's experience in the global wind industry. Our team contacted and obtained selective data through telephone interviews, e-mail contact of industry participants and a comprehensive review of currently available secondary sources. This information has been used to build a proprietary models for the US wind energy sector.

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Kinetik Partners is a boutique business consulting firm with offices in Detroit, USA and Barcelona, Spain. We help management make the big decisions on strategy, mergers & acquisitions, innovation and technology.

For more information, please visit www.kinetikpartners.com

¹ UNIVERSITY COLLABORATION ON WIND ENERGY, Cornell University, Alan T. Zehnder and Zellman Warhaft
July 27, 2011

² *Offshore Terminal Bremerhaven: Information for Infrastructure Investors*. Ministry of Economic Affairs and Ports, Free Hanseatic City of Bremen.

³ Press Release "State of Rhode Island Receives \$22.3 Million Stimulus Grant to Support Improvements at Quonset Point." Rhode Island Government. Release date: 02-17-2010 . Accessed 12/9/2011

⁴ Tetrattech Inc., *Port and Infrastructure Analysis for Offshore Wind Energy Development*. Prepared for Massachusetts Clean Energy Center. February 2010.

⁵ *Offshore Terminal Bremerhaven: Information for Infrastructure Investors*. Ministry of Economic Affairs and Ports, Free Hanseatic City of Bremen.

⁶ Kinetik Partners. "Analysis of Maryland Steel Facilities for Sufficiency to Support Offshore Wind Energy Deployment"